WASHINGTON STATE HEALTH SERVICES RESEARCH

Analysis of Hepatitis C Drug Expenditures Using Transfer Function Time Series Model

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Abstract

Washington State Health Care Authority creates policies which often affect Medicaid expenditures. Washington Medicaid expenditure forecasts are produced by integrating statistical methods with domain experts' modelling of new policies effect on expenditures. When the policy has taken place and actual expenditures are mature, forecast analysts can evaluate the particular policy's impact on expenditures. Intervention analysis using the time series method Autoregressive Integrated Moving Average with Explanatory Variable (ARIMAX) can be used for such evaluation. This paper illustrates this method by analyzing the impact of changing policies regarding Hepatitis C (HEP C) spending on total drug expenditures (Service Code 410 in the Medicaid forecast data). Specifically, the paper focuses on HEP C expenditures impact since it is paid as fee-for-service (FFS). The impact of level change is calculated to be $23.6 million. Without any other shocks or policy changes, service 410 drug expenditures new stable level or equilibrium is estimated to be $14.34 million.

Introduction

The Health Care Authority expanded coverage of Hepatitis C treatment for Medicaid recipients in January 2014 to include newly approved direct-acting antiviral treatment options. In the same month, Medicaid Expansion from the Affordable Care Act (ACA) began. ACA increased access to drugs as more people were covered and new direct-acting antiviral treatment were expensive which together increased drugs expenditures. Beginning January 1, 2015, HEP C treatments were no longer included in the Managed Care rates, and HCA began paying for HEP C drugs as FFS only. In June 2016, HCA adjusted its policy to include coverage for all clients affected by HEP C regardless of fibrosis score. Using the ARIMAX method, one can filter out noises in the time series and measure the impact of HEP C expenditures. One interpretation of the impact can be seen by observing what service 410's expenditure would have been if everything were to stay the same and compare it to the actual expenditures after the implementation of the FFS payment policy. Chart 1b illustrates this pre-fee-for-service and post-fee-for-service scenario. A joint estimation method is used (including all data points up to July 2018) in finding the impact which can be seen as the difference between the orange and blue line on Chart 1b. The modelling approach used was first fitting systematic variation attributed to the Autoregressive Moving Average (ARMA) terms and then fitting the regression terms to its residual. The final model that includes deterministic time trend (variable T) and other independent variables as shown in Table 1 yielded the lowest Akaike Information Criterion.

Analysis and Results

Washington Medicaid service 410 drug expenditures are comprised of HEP C and Non-HEP C. From Table 1, the effects of Medicaid expansion and HCA expanded coverage of HEP C (jointly as variable ACA) is estimated to be statistically significant at $6.25 million. We cannot infer how much of the $6.25 million were a result of HCA or Medicaid expansion policy. We also cannot identify the distribution of HEP C and Non-HEP C drugs from the estimated amount. However, we can conclude that together the policies increased the level of expenditures by $6.25 million.

The variable ‘FFS_Pol’ represents the effect of paying for HEP C drugs starting January 1, 2015, as fee-for-service. It is estimated to have significant impact at lag0 (contemporaneous correlation between service 410 drugs expenditure and the policy) and at lag6 (variation in policy in the current period is correlated with variation in future values of service 410 drugs expenditure). The effect is modeled as a transfer function. The numerator represents the effects of the event and the denominator measures the persistence of the effect. The “DEN1,1” parameter, is statistically significant at .80. The coefficient conveys how long it takes service 410 drug expenditures to transition back to the steady state following the policy event. The closer the coefficient is to one, the longer the persistence of the effect of the event. From the numerator factor shown in Table 1 and Table 2, it is estimated the effect of FFS policy at lag0 is $1.38 million and at lag6 is $2.86 million. The effect exponentially decays by factor .80 over time. In other words, $1.38 million is added to the expenditure the first month, $1.38 *.80^2 in the second month, etc… plus $2.86 million in the sixth month, plus $2.86*.80^1 in the seventh month, etc… See Formula Chart, Chart 2a and Chart 2b for mathematical derivation and visual representation respectively. Using geometric series convergence formula, the impact of level change is calculated to be $21.5 million.

The variable ‘HEPC_Pulse” is created to model the surge in expenditures from policy that covers all clients regardless of fibrosis score. The effect is estimated to add another $2.17 million on top of the $21.5 million for a total level impact of $23.67 million. This level reflects all the stated policies. However, we know the caseload should drop after those who are affected and treated, expenditures would decrease. Service 410 drug expenditures new stable level or equilibrium is estimated to be $14.34 million with standard error at $1.26 million. This level is the model estimated mean, which is statistically significant.

Summary

In summary, HEP C drugs costs, since being paid as fee-for-service, estimated to range from $1.38 million to $23.67 million a month. By using intervention analysis with ARIMAX, forecast analysts are able to understand the effects of HEP C expenditures without having access to underlying detail level information such as number of patients treated and cost per treatment. Actual HEP C costs is shown in Chart 1c using claims data in ProviderOne database. Much useful information were derived from using ARIMAX method and only one series of service 410 drugs expenditures was used. The analysis revealed that service 410 drugs have reached a new stable level at $14.34 million. Additionally, there were both contemporaneous and lag relationships between policy and actual expenditures in service 410 drugs. Equipped with these insights, forecast analysts can better assess HEP C models created by domain experts in subsequent forecasting periods. They should work together to understand the reasons why the HEP C modeled impact may cause service 410 drugs to deviate significantly from the new estimated mean level.

Appendix

Chart 1a: Service 410 Drugs Expenditure

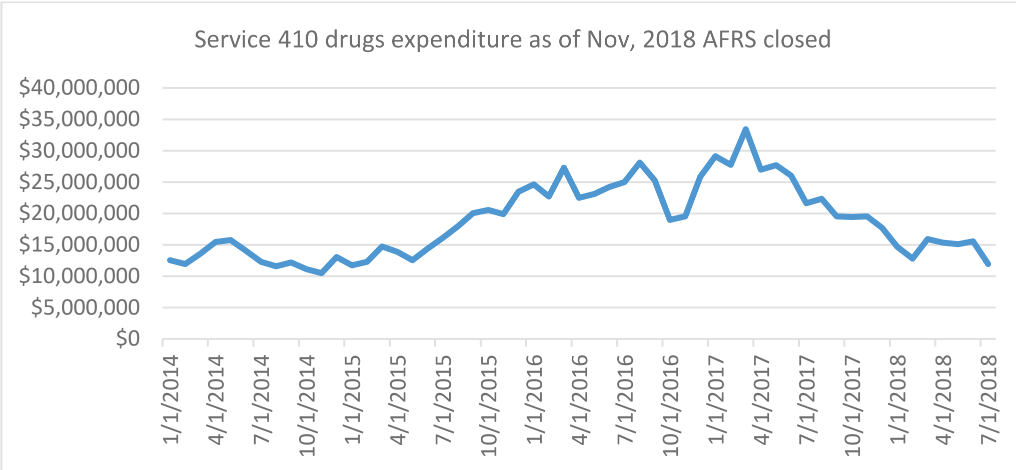

Chart 1b: Service 410 Pre-Fee-for-Service Policy Forecast vs Actual Expenditure Post Fee-for-Services Policy

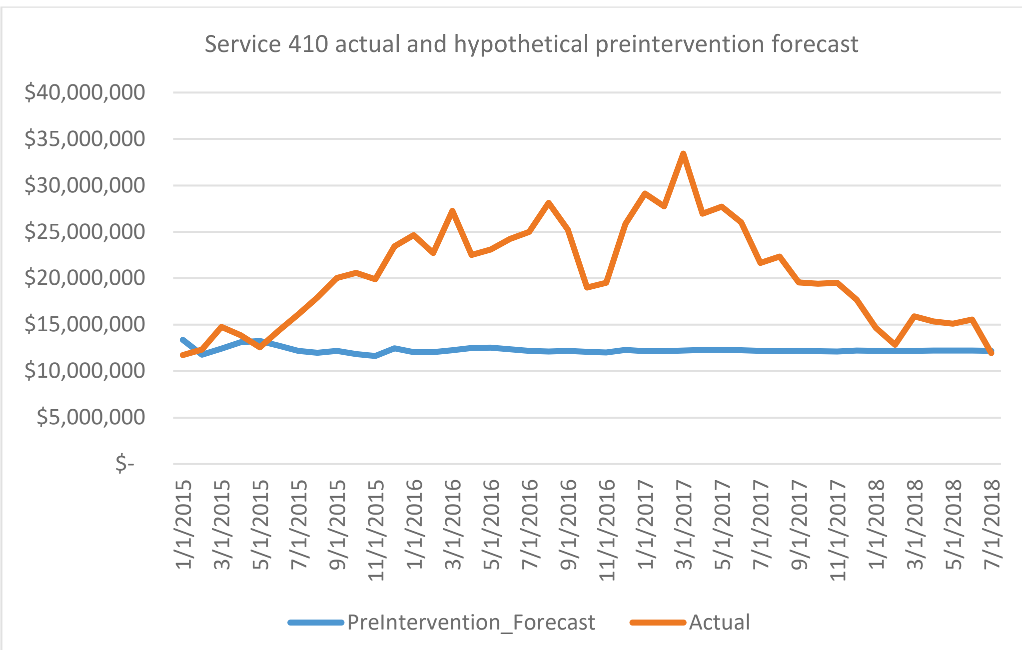

Chart 1c: Actual HEP C Expenditures, June 2019 ProviderOne Database

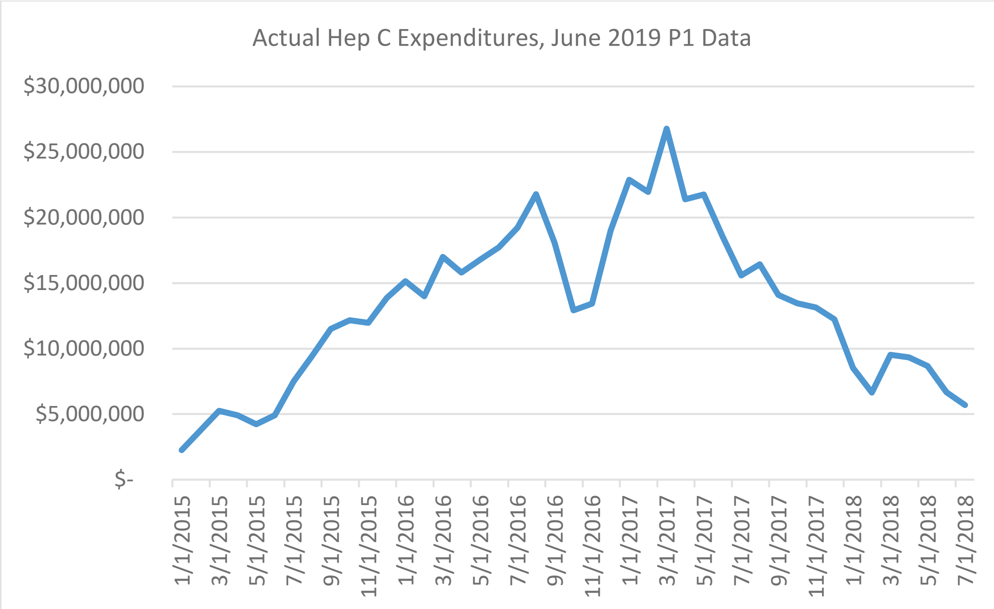

Table 1: SAS Estimation Output

Maximum Likelihood Estimation							
Parameter	**Estimate**	**Standard Error**	**T Value**	**Approx Pr > |t|**	**Lag**	**Variable**	**Shift**
MU	14342523	1261131.6	11.37	<.0001	0	_Dollar	0
AR1,1	0.31466	0.13591	2.32	0.0206	1	_Dollar	0
AR2,1	0.36653	0.14189	2.58	0.0098	12	_Dollar	0
NUM1	1387649.3	410603.7	3.38	0.0007	0	FFS_Pol	0
NUM1,1	-2863030.4	951740.4	-3.01	0.0026	6	FFS_Pol	0
DEN1,1	0.80341	0.05735	14.01	<.0001	1	FFS_Pol	0
NUM2	-415630.2	82141.6	-5.06	<.0001	0	T	0
NUM3	2175257.6	307394.0	7.08	<.0001	0	HEPC_Pulse	0
NUM4	6257102.9	1312225.3	4.77	<.0001	0	ACA	0

Formula chart:

From SAS outputs in Table 1 and Table 2, a Taylor series expansion formula can be used to describe the rational transfer function as:

$$\frac{\beta_0 - \beta_1 B}{1 - \alpha_1 B} * X_t$$
$$= \frac{1387649 \; + 2863030B^6}{1 \; - \; 0.80341 \; B} * \; X_t$$
$$(1387649 \; + 2863030B^6) * (1 + \; .80B + .80^2B^2 + .80^3B^3 \; + \cdots + .80^nB^n \;) * X_t$$
$$= 1387649Xt + .80^1(1387649)X_{t-1} + .80^2(1387649)X_{t-2} \; + \cdots + .80^n(1387649)X_{t-n} +$$
$$2863030X_{t-6} + .80^1(2863030)X_{t-7} + .80^2(2863030)X_{t-8} \; + .80^n(2863030)X_{t-n-6}$$

Chart 2a: FFS_Pol Variable Effect

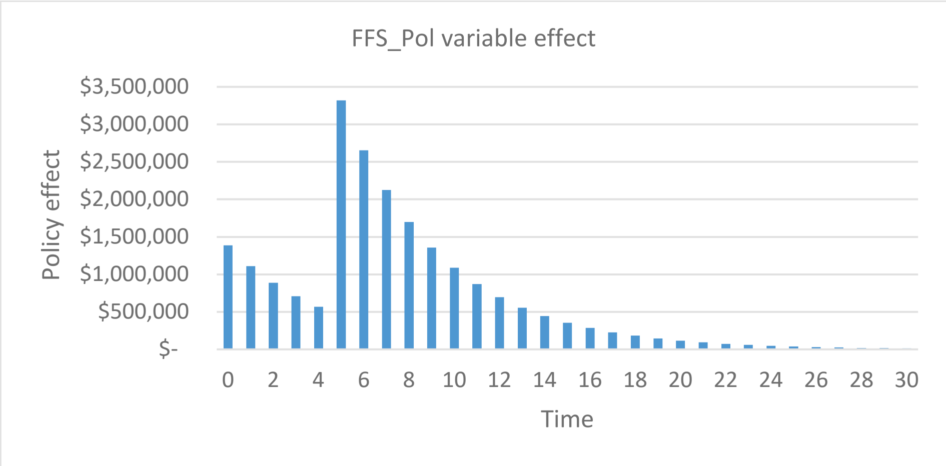

Chart 2b: FFS_Pol Variable Cumulative Effect

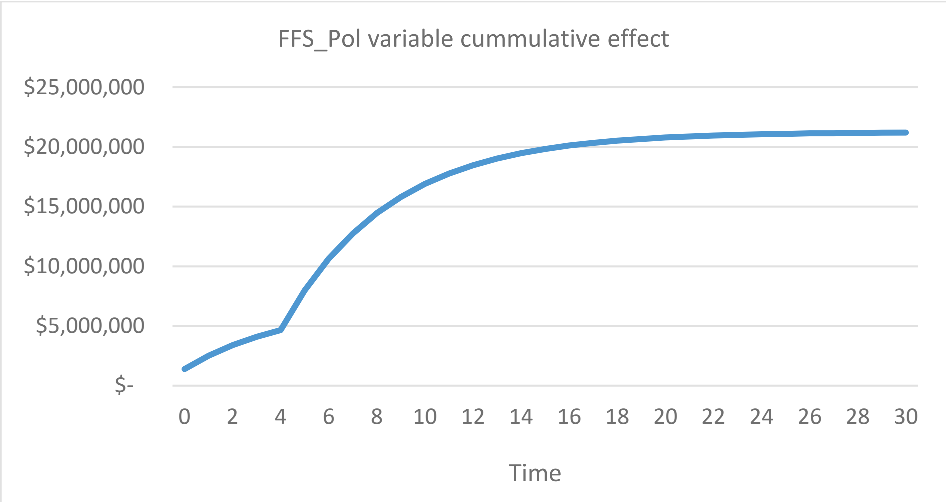

Table 2: SAS Model Outputs

Model for Variable_Dollar	
Estimated Intercept	14342523

Autoregressive Factors	
Factor 1:	1 – 0.31466 B**(1)
Factor 2:	1 – 0.36653 B**(12)

Input Number 1	
Input Variable	FFS_Pol

Numerator Factors	
Factor 1:	1387649 + 2863030 B**(6)

Denominator Factors	
Factor 1:	1 – 0.80341 B**(1)

Input Number 2	
Input Variable	T
Overall Regression Factor	-415630

Input Number 3	
Input Variable	HEPC_Pulse
Overall Regression Factor	2175258

Input Number 4	
Input Variable	ACA
Overall Regression Factor	6257103

Reference

Wen Fujian. 2011. Analysis on Promotional Campaign Effects of Direct Bill Insert Advertising Using a Transfer Function Time-Series Model. SCSUG Paper.

SAS, OnlineDoc, SAS/ETS, Version 14.2, 2015-2016. SAS Institute Inc., Cary, NC, USA.